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Experimental test of seedling recruitment response to season of fire

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Background

In many ecosystems around the world, fire is increasingly occurring outside of historical fire seasons owing to climate change (e.g., lengthening fire season) and other human activity (e.g., year-round ignitions). While many plant species have evolved alongside fire for millennia, they are often adapted to particular fire regimes, including fire in certain seasons. Unseasonal fire may cause a mismatch with the optimal timing of key plant life cycle stages (e.g., flowering, seed production, germination) and leave plant populations vulnerable to poor post-fire recovery. Field evidence from southwestern Australia and other winter rainfall ecosystems globally show that maximum recruitment is expected following summer and autumn (dry season) fire and lower recruitment may be expected from winter and spring (wet season) fire.

Banksia prionotes seedlings from an experimental sowing.

In this study, we used a seed sowing experiment to emulate the timing of fire at different times of the year and assess the effects on seedling recruitment. By using a controlled experiment, we were able track seedling emergence, seedling survival and seed persistence to help understand the mechanisms of high vs low recruitment.

Experimental seed sowing

We sowed non-dormant seeds of nine native plant species from Banksia woodlands (*Acacia, Allocasuarina, Banksia, Eucalyptus, Hakea, Kennedia* and *Melaleuca* species) monthly from May to October in a field study site at the Murdoch University Perth campus. By sowing seeds at different times, from autumn (end of dry season) through spring (end of wet season), we emulated post-fire recruitment opportunities in different seasons. The chosen study species cover a range of plant families and functional types (i.e., resprouter vs non-resprouter, canopy vs soil seed bank, tree vs shrub).

After sowing, we monitored individual seedling emergence and survival for two years. We also monitored the fate of seeds that failed to germinate after sowing and remained on the soil surface over the ensuing long, hot summer.

Experimental study site showing randomised plot (55 × 60 cm) layout with a mix of recently sown plots (darker plots) covered with ash and charred litter, previously sown plots (lighter plots) with small tags marking individual seedlings, and yet-to-be-sown plots (bare ground).

Findings

Out of 30,690 seeds sown across all species, 5,547 seedlings were recorded, mostly (93%) emerging in the first winter of the study.

As expected, seedling emergence was best from May and June sowings (Fig. 1A), with seeds cued to germinate with the first winter rains. Emergence from July sowings was lower, but seeds sown in later winter and spring (Aug-Oct) mostly missed the opportunity for germination in the first winter.

Seedling survival over the first summer was also best from seeds sown in May and June (Fig. 1B). Seedlings from these sowings mostly emerged late July-early August, providing them the longest establishment period before summer drought. The few seedlings that emerged in October from seeds sown earlier in spring (Aug-Sept) had little time to establish before summer and were all dead shortly after emergence (Fig. 1B). Overall, 17% of seedlings survived their first summer, and 88% of those survived their second summer.

Seeds that failed to germinate in the first winter, and therefore were exposed on the soil surface over the ensuing hot and dry summer, had low survival (Fig. 1C).

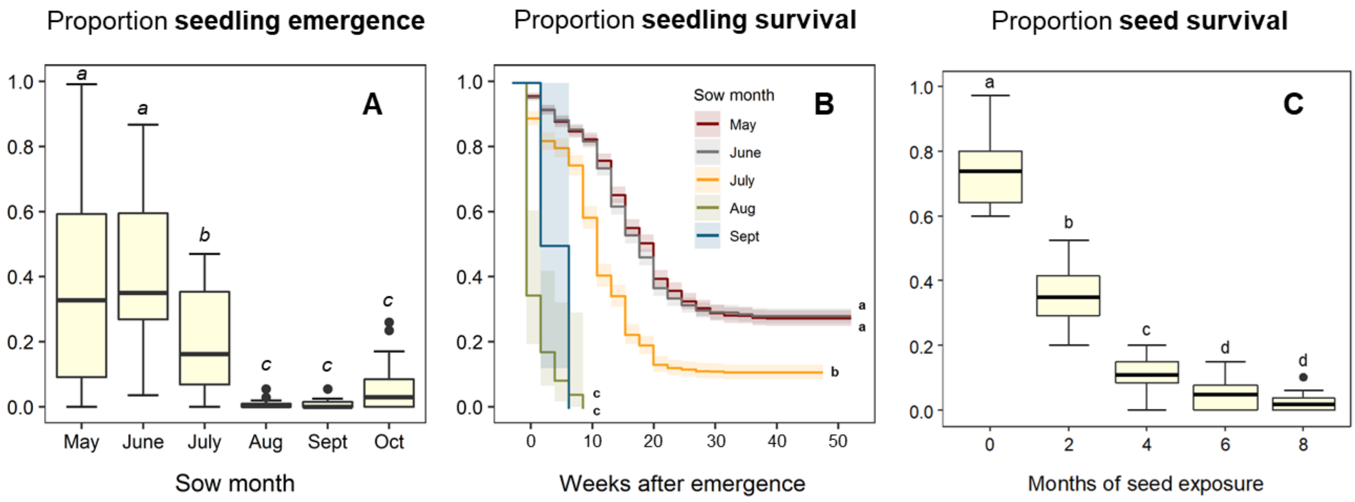

Figure 1: (A) Proportion seedling emergence over two years from different months of seed sowing, (B) proportion seedling survival over the first summer after emergence according to month of seed sowing, and (C) proportion seed survival according to the number of months of exposure on the soil surface beginning late spring. Different letters in each panel indicate a statistically significant difference based on pair-wise comparisons.

Management implications

If the timing of fire drives outcomes in the field as they have in this experiment, we would expect fire season to strongly affect post-fire seedling recruitment via altered rates of seedling emergence, seedling survival and seed persistence. However, in the field, interactions between fire season, fire severity and other factors may alter the post-fire conditions that seeds and seedlings are exposed to. For example, seasonally-varying fire severity and patchiness can affect litter and canopy consumption and therefore alter post-fire microsite conditions. Litter or shrub covered microsites that remain following a low intensity or patchy fire – which may be more likely in winter or spring burning – may partly mitigate the mechanisms we tested by helping to extend seedling establishment times and protect seeds from lethal temperatures or predation over summer.

These results indicate potential effects of fire season, and further work in the field is required to measure real-world outcomes of fire in different seasons, including the role of fire severity and other interactions in post-fire seedling recruitment in Jarrah forest. DBCA's Biodiversity and Conservation Science, in collaboration with the University of NSW and other partners, is continuing this research to inform fire management.

As climate and fire regimes change globally, understanding the vulnerability of key plant population processes to fire seasonality can help predict changes in plant populations and communities and identify species that may be most sensitive.

Further information

Miller, R.G., Fontaine J.B., Merritt, D.J., Miller, B.P. & Enright, N.J. (in press). Experimental seed sowing reveals seedling recruitment vulnerability to unseasonal fire. *Ecological Applications*.

Miller, R.G., Tangney, R., Enright, N.J., Fontaine, J.B., Merritt, D.J., Ooi, M.K.J., Ruthrof, K.X. & Miller, B.P. (2019). Mechanisms of fire seasonality effects on plant populations. *Trends in Ecology & Evolution,* 34. https://doi.org/10.1016/j.tree.2019.07.009